PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventor: ALFRED NOEL APPLEYARD

854,728

Date of filing Complete Specification: Aug. 26, 1959.

Application Date: Sept. 29, 1958. *No. 31066/58.*

Complete Specification Published: Nov. 23, 1960.

Index at acceptance:—Class 38(2), T(1F:6:7A2A).

International Classification:—H02l.

COMPLETE SPECIFICATION

Improvements relating to Electrical Transformers

SPECIFICATION NO. 854,728

INVENTOR: ALFRED NOEL APPLEYARD.

By a direction given under Section 17(1) of the Patents Act 1949 this application proceeded in the name of Associated Electrical Industries Limited, of 33, Grosvenor Place, London, S.W.1., a British Company.

THE PATENT OFFICE,
13th December, 1960.

DS 84979/1(26)/8522 200 12/60 DL

distant from and equiangularly arranged with respect to the central axis of the transformer and formed with end portions extending radially inwards towards said axis. The corresponding end portions of the respective core legs are magnetically coupled together, providing core joints each having a transverse cross-sectional dimension which is the same as the corresponding dimension across the core legs, either by suitably interleaving selected laminations of the core legs, with the remaining laminations forming butt-joints with said interleaved laminations, or by arranging that the laminations of the core legs form butt-joints with suitably shaped magnetic yoke pieces of alternate sizes which provide some overlap between the yoke pieces and the laminations.

These laminated core legs are commonly pressed into shape followed by an annealing treatment to relieve the stresses induced therein during pressing. It will be appreciated that the laminations forming the core legs must necessarily be of different lengths in order to

[*Price 3s. 6d.*]

core comprising laminated core legs which are magnetically coupled together at corresponding ends thereof by means of shaped magnetic yoke pieces interposed between successive groups, preferably pairs, of core leg laminations with a relatively large overlap being provided between each of said yoke pieces and the adjacent laminations, the thickness of said yoke pieces preferably being the same or substantially the same as the laminations while the total effective transverse cross-sectional area of the magnetic yoke pieces adjacent the respective core joints is such that under peak flux operating conditions said yoke pieces cannot saturate.

Where the yoke pieces have the same or substantially the same thickness as the core leg laminations it will be appreciated that the width of the yoke pieces adjacent the core joints will need to be appreciably greater than the width of the core laminations but the dimension through each core joint will not be as large as in the hereinbefore mentioned joint construction in which yoke pieces are alterna-

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COMPLETE SPECIFICATION

Improvements relating to Electrical Transformers

We, THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, a British Company having its registered office at 33, Grosvenor Place, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical transformers and relates more particularly to polyphase transformers of the kind having windings carried by a plurality of laminated core legs arranged parallel to each other and angularly displaced around the central axis of the transformer. The core legs may be formed with end portions extending inwardly towards the central axis.

In one known form of three-phase transformer of the kind indicated the transformer windings are carried by three laminated core legs of cruciform cross-section which are equidistant from and equiangularly arranged with respect to the central axis of the transformer and formed with end portions extending radially inwards towards said axis. The corresponding end portions of the respective core legs are magnetically coupled together, providing core joints each having a transverse cross-sectional dimension which is the same as the corresponding dimension across the core legs, either by suitably interleaving selected laminations of the core legs, with the remaining laminations forming butt-joints with said interleaved laminations, or by arranging that the laminations of the core legs form butt-joints with suitably shaped magnetic yoke pieces of alternate sizes which provide some overlap between the yoke pieces and the laminations.

These laminated core legs are commonly pressed into shape followed by an annealing treatment to relieve the stresses induced therein during pressing. It will be appreciated that the laminations forming the core legs must necessarily be of different lengths in order to compensate for the varying radii of the laminations at each bend in the core legs and it is extremely difficult to ensure that the laminations of the core legs when formed and subsequently coupled together as aforesaid do not define excessively large air gaps at the butt-joints previously referred to, thereby giving rise to high core losses and high magnetising currents when the transformer is operating.

The above difficulty may be overcome by avoiding the use of butt-joints in the core joints and relying upon a relatively large overlap between the laminations of the core legs and suitably shaped magnetic yoke pieces having parts thereof introduced between alternate laminations of said core legs. In such an arrangement, however, the dimension through the core joint will be undesirably large.

According to the present invention there is provided in or for an electrical transformer of the kind hereinbefore indicated, a magnetic core comprising laminated core legs which are magnetically coupled together at corresponding ends thereof by means of shaped magnetic yoke pieces interposed between successive groups, preferably pairs, of core leg laminations with a relatively large overlap being provided between each of said yoke pieces and the adjacent laminations, the thickness of said yoke pieces preferably being the same or substantially the same as the laminations while the total effective transverse cross-sectional area of the magnetic yoke pieces adjacent the respective core joints is such that under peak flux operating conditions said yoke pieces cannot saturate.

Where the yoke pieces have the same or substantially the same thickness as the core leg laminations it will be appreciated that the width of the yoke pieces adjacent the core joints will need to be appreciably greater than the width of the core laminations but the dimension through each core joint will not be as large as in the hereinbefore mentioned joint construction in which yoke pieces are alterna-

ted with the core leg laminations. For example if the yoke pieces and core laminations have the same permeability as is especially contemplated and the yoke pieces inserted between successive pairs of laminations then the width of each yoke piece adjacent the relevant core joint will be twice that of the core laminations.

A better understanding of the present invention may be had from the following description taken in conjunction with the drawings accompanying the Provisional Specification, in which:

Figs. 1 and 2 are diagrammatic end views of a three-phase transformer illustrating alternative core joints of known form;

Fig. 3 is a view similar to that of Figs. 1 and 2 of an exemplary embodiment of the present invention; and

Fig. 4 is a part of a sectional view taken along the line X—X in Fig. 3.

Referring to Fig. 1 of the drawings, the three-phase transformer comprises sets of windings 1, 2 and 3 which are respectively arranged on parallel core legs 4, 5 and 6 of rectangular cross-section. Each of these core legs consists of a multiplicity of superposed grain-oriented iron laminations and is formed integrally with two end portions, one of which is indicated at 7, which extend at right-angles to the axis of the windings on said leg and radially inwardly towards the central longitudinal axis of the transformer. As can be seen from the figure, the laminated core legs, 4, 5, and 6 are equidistant from and arranged equiangularly about the last-mentioned axis. The three core legs are magnetically coupled together at corresponding end portions 7 by providing the outermost lamination of the core leg 4 and every third lamination thereafter in said legs with a triangular extension 8 and by similarly providing such extensions (not shown) on the second and third laminations from the outermost laminations of the legs 5 and 6 respectively and on every third lamination thereafter in said legs. These triangular extensions interleave with each other while the intermediate laminations of the core legs without such extensions form butt-joints, such as indicated at 9, with one or other of the sides of said extensions. Referring now to Fig. 2 of the drawings, the three-phase transformer illustrated is of the same general construction as that illustrated in Fig. 1 and like designations have accordingly been employed to indicate like parts. The essential difference between the Fig. 1 and Fig. 2 constructions resides in the manner of forming the joints between the core legs 4, 5 and 6. The outermost laminations of the core leg form butt-joints 10 with the respective sides of a triangular magnetic yoke piece 11 while the next laminations in the core legs terminate short of the outer laminations and form butt-joints such as 12 with one side of a hexagonal iron yoke piece 13 located immediately below triangular yoke piece 11. This pattern is repeated throughout the entire joint for the remaining pairs of laminations in each core leg.

The core legs 4, 5 and 6 of the Fig. 1 and Fig. 2 transformer construction are conveniently formed by pressing laminations of suitably graded lengths and then subjecting the core legs so formed to an annealing treatment, but unless extreme care is exercised both in assembling the laminations and pressing the legs into their final shape the extreme ends of these laminations will be incorrectly positioned in the formed legs thereby producing excessively large air gaps at the butt-joints 9, 10 and 12 resulting in increased core losses and increased magnetising currents when the transformer is operating.

Figs. 3 and 4 of the drawings illustrate a three-phase transformer constructed in accordance with the invention, those parts of the transformer also shown in Figs. 1 and 2 bearing like designations. As can be seen in Figs. 3 and 4 the core legs 4, 5 and 6 are magnetically connected together by hexagonal yoke pieces 13 preferably of non grain-oriented iron of substantially the same thickness as laminations 14 forming the core legs and having parts thereof located between successive pairs of core laminations with a large area of overlap being provided between the yoke pieces 13 and the adjacent laminations. Consequently it is not important that the ends of the laminations 14 should be co-terminus and Fig. 4 in fact shows the ends of these laminations as being variably displaced from each other in the horizontal direction and clearly demonstrates that the core legs need not be formed with the same degree of precision as regards the final disposition of the ends of laminations 14 as is required with the joint constructions shown in Figs. 1 and 2.

Since the iron yoke pieces 13 are of substantially the same thickness as the core laminations 14 the width of said yoke pieces adjacent the core joint must be somewhat greater than the width of the laminations 14 so that the total effective transverse cross-sectional area of the yoke pieces adjacent the core joint is not less than that of the core legs. In the particular construction illustrated, the width of the yoke pieces 13 taken along the line W (i.e. adjacent the core joint) is twice the width of the laminations forming the core.

It can be seen from Fig. 4 that the insertion of the yoke pieces 13 between successive pairs of laminations 17 inevitably increases the overall cross-sectional dimension through the core joint as compared with the Fig. 1 and Fig. 2 joint constructions but not unduly as would be the case if narrower yoke pieces were inserted between each pair of laminations. The weight of material at the joint is also greater than in the Fig. 1 and Fig. 2 constructions but this is tolerable in view of re-

duced core losses.

Although the yoke pieces 13 are shown as being introduced between successive pairs of laminations it will be understood that yoke pieces of even wider dimensions may for example be introduced between successive groups of three or even more laminations. Moreover, the cross-sectional configuration of the core legs may be varied by using laminations of suitably graded widths in which case the dimensions of the yoke pieces will be varied accordingly.

In forming the core legs of a transformer according to the invention removable spacers may be introduced between the ends of successive pairs of laminations so as to provide in the formed legs openings for the insertion of the yoke pieces 13. When the core legs have been formed the transformer windings will be arranged thereon and the yoke pieces simply inserted between the appropriate laminations after the core legs and windings have been arranged in their final positions. Core clamping means to hold the yoke pieces and core legs in place may take any convenient form.

WHAT WE CLAIM IS:—

1. In or for an electrical transformer of the kind hereinbefore set forth, a magnetic core comprising laminated core legs which are magnetically coupled together at corresponding ends thereof by means of magnetic yoke pieces interposed between successive groups of core leg laminations with a relatively large overlap being provided between each of said yoke pieces and the adjacent laminations, the total effective transverse cross-sectional area of the magnetic yoke pieces adjacent the respective core joints being such that under peak flux operating conditions said yoke pieces cannot saturate.

2. A magnetic core as claimed in Claim 1, in which magnetic yoke pieces are interposed between successive pairs of core leg laminations.

3. A magnetic core as claimed in Claim 1 or Claim 2, in which the thickness of the magnetic yoke pieces is the same or substantially the same as that of the core leg laminations.

4. A magnetic core as claimed in any preceding Claim, in which each of the magnetic yoke pieces is of hexagonal shape and preferably composed of non grain-oriented iron.

5. A three-phase electrical transformer comprising a magnetic core substantially as herein described with reference to Figs. 3 and 4 of the drawings accompanying the Provisional Specification.

J. W. RIDDING,
Chartered Patent Agent,
Crown House, Aldwych, London, W.C.2,
Agent for the Applicants.

PROVISIONAL SPECIFICATION

Improvements relating to Electrical Transformers

We, THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, a British Company having its registered office at Crown House, Aldwych, London, W.C.2, do hereby declare this invention to be described in the following statement:

This invention relates to electrical transformers and relates more particularly to polyphase transformers of the kind having windings carried by a plurality of laminated core legs arranged parallel to each other and angularly displaced around the central axis of the transformer. The core legs may be formed with end portions extending inwardly towards said central axis.

In one known form of three-phase transformer of the kind indicated the transformer windings are carried by three laminated core legs of cruciform cross-section which are equidistant from and equiangularly arranged with respect to the centtral axis of the transformer and formed with end portions extending radially inwards towards said axis. The corresponding end portions of the respective core legs are magnetically coupled together, providing core joints each having a transverse cross-sectional dimension which is the same as the corresponding dimension across the core legs, either by suitably interleaving selected laminations of the core legs, with the remaining laminations forming butt-joints with said interleaved laminations, or by arranging that the laminations of the core legs form butt-joints with suitably shaped magnetic yoke pieces of alternate sizes which provide some overlap between the yoke pieces and the laminations.

These laminted core legs are commonly pressed into shape followed by an annealing treatment to relieve the stresses induced therein during pressing. It will be appreciated that the laminations forming the core legs must necessarily be of different lengths in order to compensate for the varying radii of the laminations at each bend in the core legs and it is extremely difficult to ensure that the laminations of the core legs when formed and subsequently coupled together as aforesaid do not define excessively large air gaps at the butt joints previously referred to, thereby giving rise to high core losses and high magnetising currents when the transformer is operating.

The above difficulty may be overcome by avoiding the use of butt-joints in the core joints and relying upon a relatively large overlap between the laminations of the core legs and suitably shaped magnetic yoke pieces having parts thereof introduced between alternate laminations of said core legs. In such an arrangement, however, the dimension

through the core joint will be undesirably large.

According to the present invention there is provided in or for an electrical transformer of the kind hereinbefore indicated, a magnetic core comprising laminated core legs which are magnetically coupled together at corresponding ends thereof by the intervention of suitably shaped magnetic yoke pieces between successive groups, preferably pairs of core leg laminations with a relatively large overlap between said yoke pieces and adjacent laminations, the thickness of said yoke pieces preferably being the same or substantially the same as the laminations while the total effective transverse cross-sectional area of the magnetic yoke pieces adjacent the respective core joints is such that under peak flux operating conditions said yoke pieces will not saturate.

Where the yoke pieces have the same or substantially the same thickness as the core leg laminations it will be appreciated that the width of the yoke pieces adjacent the core joints will need to be appreciably greater than the width of the core laminations but the dimension through each core joint will not be as large as in the hereinbefore mentioned joint construction in which yoke pieces are alternated with the core leg laminations. For example, if the yoke pieces and core laminations have the same permeability as is especially contemplated and the yoke pieces inserted between successive pairs of laminations then the width of each yoke piece adjacent the relevant core joint will be twice that of the core laminations.

A better understanding of the present invention may be had from the following description taken in conjunction with the accompanying drawings, in which:—

Figs. 1 and 2 are diagrammatic end views of a three phase transformer illustrating alternative core joints of known form;

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The core legs 4, 5 and 6 of the Fig. 1 and Fig. 2 transformer construction are conventionally formed by pressing laminations of suitably graded lengths and then subjecting the core legs so formed to an annealing treatment, but unless extreme care is exercised both in assembling the laminations and pressing the legs into their final shape the extreme ends of these laminations will be incorrectly positioned in the formed legs thereby producing excessively large air gaps at the butt-joints 9, 10 and 12 resulting in increased core losses and increased magnetising currents when the transformer is operating.

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Although the yoke pieces 13 are shown as being introduced between successive pairs of laminations it will be understood that yoke pieces of even wider dimensions may for example be introduced between successive groups of three or even more laminations. Moreover, the cross-sectional configuration of the core legs may be varied by using laminations of suitably graded widths in which case the dimensions of the yoke pieces will be varied accordingly.

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Agent for the Applicants.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1960.
Published by The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

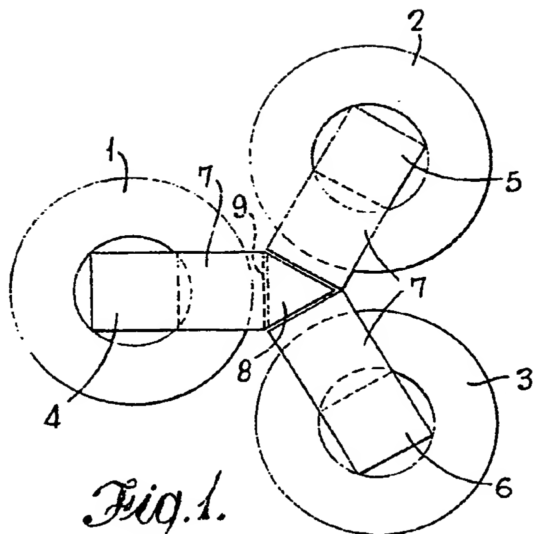

Fig.1.

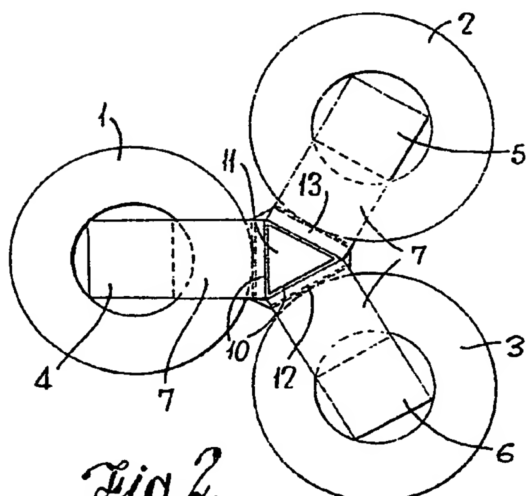

Fig.2.

854,728 PROVISIONAL SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 1 & 2

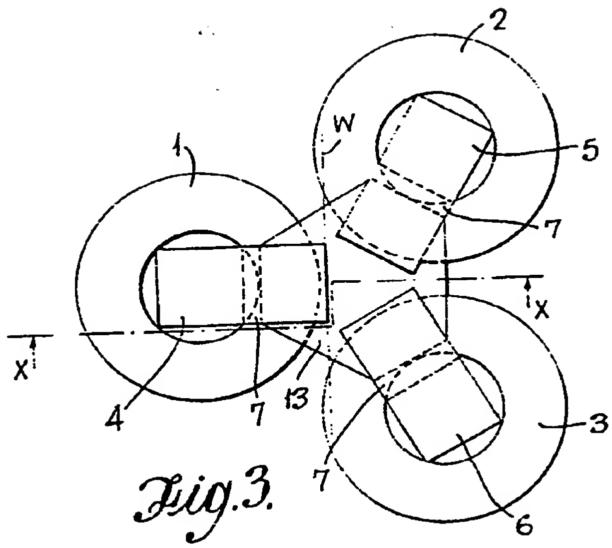

Fig.3.

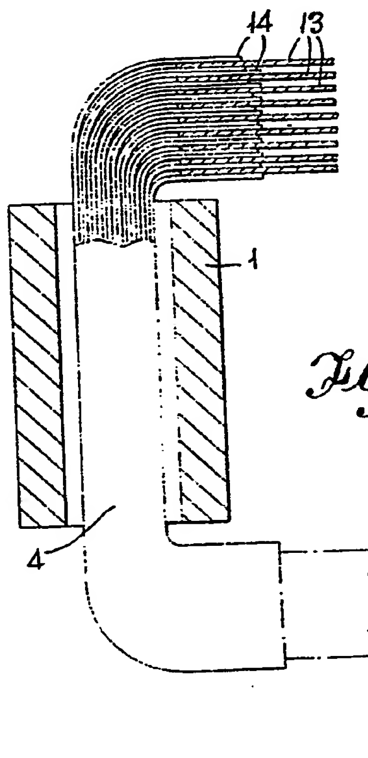

Fig.4.

854,728 PROVISIONAL SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

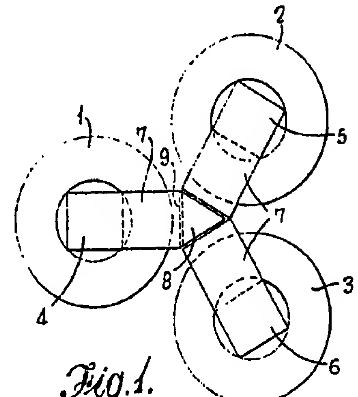

Fig.1.

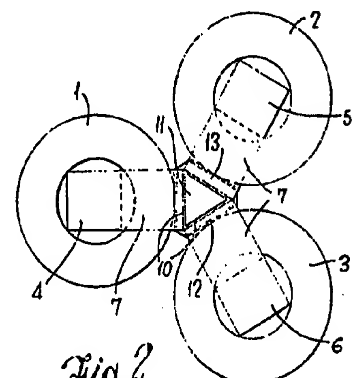

Fig.2.

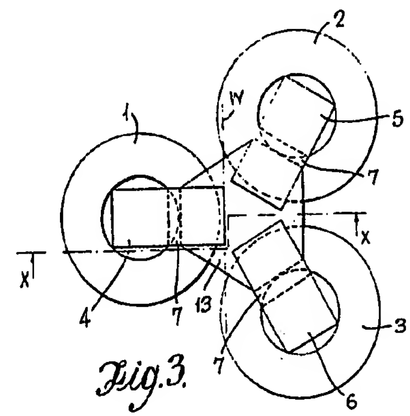

Fig.3.

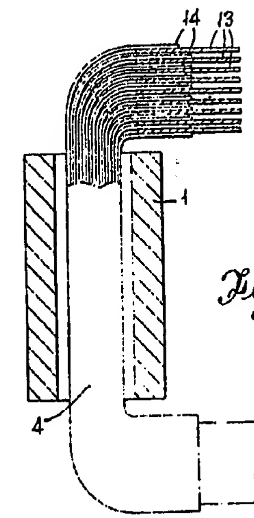

Fig.4.